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(54) **Laminate structural bulkhead**

Laminierte Trennwand

Cloison structurelle laminée

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**WO-A-96/37400**
**US-A- 2 327 585**
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## Description

**[0001]** Particularly in automotive applications, box sections such as main frame rails are subjected to considerable stress forces where cross members are bolted to the rails. For example, when engine cradles are bolted to main frame rails they produce joints that are susceptible to durability cracking over time. In addition, the bolts which hold such components in place may loosen due to vibration at the joint. Moreover, conventional structures create a "noise path" which extends from the vehicle wheels and engine through the frame and into the passenger compartment.

**[0002]** As will be appreciated by those skilled in the art, in order to bolt a heavy component to the side of a rail section it is necessary to create a reinforced region or support structure at the site of attachment of the bolt. One approach which is used in the art is to provide a stamped bulkhead which supports a metal bushing. The bulkhead generally has three flange portions which are spot welded to the rail C-section. More specifically, the stamped bulkhead has a wall portion that extends from one wall of the rail section to the opposite wall or cap. Thus, the bulkhead forms a partition in the channel or cavity defined by the rail. In order to secure this wall portion in place, the bulkhead has three surfaces or flanges that are perpendicular to the bulkhead wall portion; that is, the bulkhead is in essence a shallow rectangular box that is open on one side. These three surfaces mate with the inner surfaces of the rail and are spot welded in place.

**[0003]** In order to utilize the bulkhead as a support for the cross structure which is attached thereto, it is designed to position a metal bushing that is spot welded to the bulkhead stamping. A bolt then passes through the bushing and secures the cross structure to the rail at the bulkhead-reinforced region. This conventional approach will be more fully illustrated hereinafter.

**[0004]** While the conventional bulkhead design does serve to reinforce the rail section at the attachment site of the cross member, it generally requires large gauge bushings and stampings and can actually increase unwanted vibration and noise. Moreover, the through-bolt, bushing, metal stamping and rail section essentially perform as discrete elements more than a unitary, integral reinforcement structure. This results not only in the above-mentioned increase in vibration and noise, but also fails to provide full reinforcement of the rail, resulting in metal fatigue at the joint and, in particular, at weld locations.

**[0005]** The present inventor has developed a number of approaches to the reinforcement of hollow metal parts such as: a reinforcing beam for a vehicle door which comprises an open channel-shaped metal member having a longitudinal cavity which is filled with a thermoset or thermoplastic resin-based material; a hollow torsion bar cut to length and charged with a resin-based material; a precast reinforcement insert for structural members which is formed of a plurality of pellets containing a thermoset resin with a blowing agent, the precast member being expanded and cured in place in the structural member; a composite door beam which has a resin-based core that occupies not more than one-third of the bore of a metal tube; a hollow laminate beam characterized by high stiffness-to-mass ratio and having an outer portion which is separated from an inner tube by a thin layer of structural foam; an I-beam reinforcement member which comprises a preformed structural insert having an external foam which is then inserted into a hollow structural member; and a metal w-shaped bracket which serves as a carrier for an expandable resin which is foamed in place in a hollow section. The latter is disclosed in WO96/37400 which describes a w-shaped reinforcement member that carries a thermally expandable resin based material. A slot in the reinforcement member allows it to be placed over a pin whereupon it is heated to expand a resin based material which locks the reinforcement member into place.

**[0006]** It is an object of the present invention to provide a reinforced hollow metal structure which incorporates a bushing and a stamping in a bulkhead structure in a manner in which the components of the bulkhead work together as an integral unit with the reinforced structure.

**[0007]** It is a further object of the invention to provide a reinforced metal box section which provides greater strength to the section without significantly increasing vibration and noise transmission levels.

**[0008]** It is a further object of the present invention to provide a reinforced frame rail section at the attachment of a cross member such as an engine cradle in a manner in which stress forces are distributed over a region of the reinforced rail rather than at the discrete welds and in which noise and vibration are dampened.

**[0009]** These and other objects and advantages of the invention will be more fully appreciated in accordance with the detailed description of the preferred embodiments of the invention and the drawings.

**[0010]** In one aspect the present invention provides a reinforced structure. The reinforced structure includes a hollow structural member and a reinforcing member disposed therein. The reinforcing member has a pair of opposed walls. A layer of thermally expanded polymer is disposed between and is bonded to the opposed walls. This layer of polymer is also bonded directly to the structural member. A sleeve extends through the polymer parallel with and between the opposed walls. The polymer is bonded to the sleeve and the sleeve defines a passage through the polymer. The reinforced structure has holes that are in alignment with the ends of the sleeve. A bolt is then used to secure a component to the structural member. Thus, the hollow structural member is reinforced locally in the present invention at that position by virtue of the reinforcing member. The polymer is expanded in place by heating the entire structure after assembly, where it expands to fill gaps between the reinforcing structure and the structural member and bonds the reinforcing structure to the structural member.

**[0011]** In another aspect the reinforced structure of the present invention is a motor vehicle rail such as a front rail where local reinforcement for the attachment of components such as an engine cradle is required. In this aspect, the invention reduces vibration and noise transmission as well as increases the strength of the part at the site of the reinforcement.

**[0012]** In still another aspect the sleeve is a thin wall metal bushing, the opposed walls are metal stampings with flanges which are welded to the structural member and the polymer is a thermally expanded epoxy resin which contains hollow microspheres for density reduction.

**[0013]** In still another aspect the present invention provides method of reinforcing a structural member having a longitudinal channel. In this aspect a laminated structure having two opposed walls separated by a layer of thermally expandable polymer is placed in the channel of a rail section or the like. The laminated structure has a sleeve disposed in the layer of thermally expandable polymer. The sleeve defines a passage perpendicular to the opposed walls. The laminated structure also has a pair of end flanges. The laminated structure is placed in the longitudinal channel such that said sleeve passage is perpendicular to the longitudinal channel. The laminated structure is then welded to the structural member at the flanges. The entire structure is then heated to a temperature effective to activate the blowing agent of the polymer and thereby thermally expand the polymer such that it bonds the laminated structure to the structural member.

**[0014]** The invention will be further described, by way of example only, with reference to the following figures in which:

Figure 1 is a diagrammatic exploded perspective view of a conventional prior art bulkhead reinforcement structure;
Figure 2 is a diagrammatic front elevational view of the structure of Figure 1 with the cap plate removed;
Figure 3 is a diagrammatic exploded perspective view of the reinforced rail section of the present invention illustrating the construction of the reinforcing laminate bulkhead;
Figure 4 is a diagrammatic front elevational view of the structure shown in Figure 3 with the cap plate removed; and
Figure 5 is a diagrammatic back view of the bulkhead portion of Figures 3 and 4.

**[0015]** Referring now to Figures 1 and 2 of the drawings, prior art front rail section 20 is shown having C-section 22 that defines channel 23 and which receives cap plate 24. Bulkhead stamping 26 is seen having vertical wall 28 and flanges 30. Bushing 32 is welded to wall 28 at an arcuate bend 33 in wall 28. Flanges 30 are welded to section 22 to hold bulkhead 26 in place. Bolt 36 extends through cap 24, bushing 32 and vertical wall 37 of section 22 and then through a component 38 which is to attached to rail 20. Nut 40 is then attached to bolt 36 to secure component 38 in place. This is representative of the prior art and suffers from the drawbacks described above, i.e. inadequate reinforcement, inadequate sound dampening and vibration problems.

**[0016]** Turning now to Figure 3 of the drawings, reinforced structure 50 is shown in one embodiment as a reinforced front rail of an automotive frame and includes frame rail C-section 52 which is closed by cap plate 54 such that channel or cavity 56 is defined in reinforced structure 50. In other words the frame rail is hollow. C-section 52 includes vertical wall portion 58 and opposed wall portions 60 and 62. Each opposed wall portion 60,62 has a flange portion 64 of the attachment of cap plate 54 by welding or the like at the flange areas. Reinforcing member or bulkhead 68 is seen disposed in channel 56 of C-section 52 and has a first wall or side 70 and a second wall or side 72. Walls 70 and 72 are parallel to one another and are separated by polymer layer 74; that is, polymer layer 74 is disposed between walls 70 and 72.

**[0017]** As best seen in Figures 4 and 5 of the drawings, each wall 70,72 has an associated arcuate portion (76 for wall 72 and 78 for wall 70) which is designed to accommodate sleeve 81 in a manner to be more fully described hereinafter. Each arcuate portion 76,78 is approximately midway along the length of each wall 70,72 and can be viewed as a curved inner surface. Sleeve 81 is a metal bushing or the like and, as best seen in Figure 4 of the drawings is spot welded to walls 70 and 72 at weld points 83 and 85. Polymer layer 74 essentially envelopes sleeve 81 as shown in Figure 4.

**[0018]** Bulkhead 68 is secured in place in channel 56 by virtue of attachment flanges 80 and 82 which extend from walls 70 and 72 at 90 degree angles. That is, each wall 70, 72 has at each end a bent portion that mates with a similar portion on the opposed wall to form an attachment flange 80,82 that is welded on side wall 60,62, respectively.

**[0019]** The width of walls 70 and 72 (distance between vertical wall 58 and cap plate 54) is such that bulkhead 68 is in contact with vertical wall 58 and cap plate 54. Accordingly, bolt 84 extends through cap plate 54 at hole 66, through sleeve 81 and through a corresponding hole in vertical wall 58 (not shown). Bolt 84 then extends through a hole in a cross member such as engine cradle 86 which is shown in phantom as fragment 86. Nut 88 is then secured on bolt 84 to secure engine cradle 86 onto reinforced structure 50.

**[0020]** Bulkhead 68 is a relatively light weight structure for the amount of strength added to the frame rail. Walls 70 and 72 can be formed of thin steel stampings, for example from (.02 to about .08 inch) in thickness. Mild to medium strength steel is particularly preferred. Also, sleeve 81 which is preferably a metal bushing may b a thin wall tube having a wall thickness of from about 0.5 to about 2.0 mm (.08 to about .2 inch) and is preferably mild steel. Of course, these

dimensions are merely illustrative and are not intended to limit the full scope of the invention as defined in the claims. Each attachment flange 80,82 is generally from about 15 percent to about 30 percent of the length of walls 70,72. The outer diameter of sleeve 81 will typically be from about 12.7 to about 25.4 mm (½ to about 1 inch). The width of polymer layer 74 will be a function of the distance between walls or plates 70 and 72 and will generally be between about 2.5 and 10.0 mm (about .1 and about .4 inch). It is to be understood that the entire depth of bulkhead 68 is filled with polymer layer 74; that is, as shown in Figure 5 of the drawings polymer layer 74 extends from the front of bulkhead 68 to the back.

**[0021]** The polymer used to form polymer layer 74 is a resin based material which is thermally expandable. A number of resin-based compositions can be utilized to form thermally expanded layer 74 in the present invention. The preferred compositions impart excellent strength and stiffness characteristics while adding only marginally to the weight. With specific reference now to the composition of layer 74, the density of the material should preferably be from about 320 $kg/m^3$ (20 pounds per cubic feet) to about 800 $kg/m^3$ (50 pounds per cubic feet) to minimize weight. The melting point, heat distortion temperature and the temperature at which chemical breakdown occurs must also be sufficiently high such that layer 74 maintains its structure at high temperatures typically encountered in paint ovens and the like. Therefore, layer 74 should be able to withstand temperatures in excess of 160°C (320 degrees F.) and preferably 177°C (350 degrees F.) for short times. Also, layer 74 should be able to withstand heats of about 32°C (90 degrees F.) to 93°C (200 degrees F.) for extended periods without exhibiting substantial heat-induced distortion or degradation.

**[0022]** The foam 74 may be initially applied to one or both walls 70,72 and then expanded into intimate contact with both walls and with sleeve 81. Advantageously heat from the paint oven may be used to expand foam 74 when it is heat expandable.

**[0023]** In more detail, in one particularly preferred embodiment thermally expanded structural foam for layer 74 includes a synthetic resin, a cell-forming agent, and a filler. A synthetic resin comprises from about 40 percent to about 80 percent by weight, preferably from about 45 percent to about 75 percent by weight, and most preferably from about 50 percent to about 70 percent by weight of layer 74. Most preferably, a portion of the resin includes a flexible epoxy. As used herein, the term "cell-forming agent" refers generally to agents which produce bubbles, pores, or cavities in layer 74. That is, layer 74 has a cellular structure, having numerous cells disposed throughout its mass. This cellular structure provides a low-density, high-strength material, which provides a strong, yet lightweight structure. Cell-forming agents which are compatible with the present invention include reinforcing "hollow" microspheres or microbubbles which may be formed of either glass or plastic. Also, the cell-forming agent may comprise a blowing agent which may be either a chemical blowing agent or a physical blowing agent. Glass microspheres are particularly preferred. Where the cell-forming agent comprises microspheres or macrospheres, it constitutes from about 10 percent to about 50 percent by weight, preferably from about 15 percent to about 45 percent by weight, and most preferably from 20 percent to about 40 percent by weight of the material which forms layer 74. Where the cell-forming agent comprises a blowing agent, it constitutes from about 0.5 percent to about 5.0 percent by weight, preferably from about 1 percent to about 4.0 percent by weight, and most preferably from about 1 percent to about 2 percent by weight of thermally expanded structural foam layer 74. Suitable fillers include glass or plastic microspheres, fumed silica, calcium carbonate, milled glass fiber, and chopped glass strand. A thixotropic filler is particularly preferred. Other materials may be suitable. A filler comprises from about 1 percent to about 15 percent by weight, preferably from about 2 percent to about 10 percent by weight and most preferably from about 3 percent to about 8 percent by weight of layer 74.

**[0024]** Preferred synthetic resins for use in the present invention include thermosets such as epoxy resins, vinyl ester resins, thermoset polyester resins, and urethane resins. It is not intended that the scope of the present invention be limited by molecular weight of the resin and suitable weights will be understood by those skilled in the art based on the present disclosure. Where the resin component of the liquid filler material is a thermoset resin, various accelerators, such as imidizoles and curing agent, preferably dicyandiamide may also be included to enhance the cure rate. A functional amount of accelerator is typically from about 0.5 percent to about 2.0 percent of the resin weight with corresponding reduction in one of the three components, resin, cell-forming agent or filler. Similarly, the amount of curing agent used is typically from about 1 percent to about 8 percent of the resin weight with a corresponding reduction in one of the three components, resin, cell-forming agent or filler. Effective amounts of processing aids, stabilizers, colorants, UV absorbers and the like may also be included in layer. Thermoplastics may also be suitable.

**[0025]** In the following table, a preferred formulation for layer 74 is set forth. It has been found that this formulation provides a material which full expands and cures at about 160°C (320 degrees F.) and provides excellent structural properties. All percentages in the present disclosure are percent by weight unless otherwise specifically designated.

| INGREDIENT | PERCENTAGE BY WEIGHT |
|---|---|
| EPON® 828 (epoxy resin) | 37.0 |
| DER 331® (flexible epoxy resin) | 18.0 |

(continued)

| INGREDIENT | PERCENTAGE BY WEIGHT |
|---|---|
| DI-CY (dicyandiamide curing agent) | 4.0 |
| IMIDIZOLE (accelerator) | 0.8 |
| FUMED SILICA (thixotropic filler) | 1.1 |
| CELOGEN® AZ199 (asodicarbonamide blowing agent) | 1.2 |
| 83 MICROS® (glass microspheres) | 37.0 |
| WINNOFIL® CALCIUM CARBONATE ($C_aCO_3$ filler) | 0.9 |

**[0026]** While the invention has been described primarily in connection with vehicle parts, it is to be understood that the invention may be practiced as part of other products, such as aircrafts, ships, bicycles or virtually anything that requires energy for movement. Similarly, the invention may be used with stationary or static structures, such as buildings, to provide a rigid support when subjected to vibration such as from an earthquake or simply to provide a lightweight support for structures subjected to loads. Additionally, while the invention has been described primarily with respect to heat expandable foams and with respect to metal parts such as the inner tubes 16, 58 and 76, other materials can be used. For example, the foam could be any suitable known expandable foam which is chemically activated into expansion and forms a rigid structural foam. The bulkhead walls 70,70 and sleeve 81 could be made of materials other than metal such as various plastics or polymeric materials or various wood type fibrous materials having sufficient rigidity to function as a back drop or support for the foam. Where a heat expandable foam is used the bulkhead walls and sleeve should be able to withstand the heat encountered during the heat curing. Where other types of foam materials are used, however, it is not necessary that the bulkhead walls and sleeve be able to withstand high temperatures. Instead, the basic requirement for the bulkhead walls and sleeve is that it have sufficient rigidity to function in its intended manner. It is also possible, for example, to use as the bulkhead walls and sleeve materials which in themselves become rigid upon curing or further treatment. The invention may also be practiced where the bulkhead walls and sleeve are made of materials other than metal. It is preferred, however, that materials be selected so that the thin unexpanded foam upon expansion forms a strong bond with the bulkhead walls and sleeve so that a structural composition will result.

**[0027]** While particular embodiments of this invention are shown and described herein, it will be understood, of course, that the invention is not to be limited thereto since many modifications may be made, particularly by those skilled in this art, in light of this disclosure. It is contemplated, therefore, by the appended claims, to cover any such modifications as fall within the true spirit and scope of this invention.

## Claims

1. A reinforced structure (50), comprising a structural member (52) defining a space (56); a reinforcing member (68) disposed in said space, said reinforcing member having first (70) and second (72) opposed walls; a layer of expanded polymer (74) disposed between and bonded to said first and second opposed walls, said expanded polymer also being bonded to said structural member; characterised in that a sleeve (81), formed as a bushing extends through said expanded polymer (74), said sleeve (81) being fixed between said first (70) and second (72) opposed walls, said expanded polymer being bonded to said sleeve (81); and said sleeve defining a passage adapted to receive a bolt (84).

2. The reinforced structure recited in claim 1, further including a bolt (84) which extends through said structural member (52) and which extends through said sleeve (81).

3. The reinforced structure recited in claim 1 or 2, wherein said reinforced structure is an automotive rail section.

4. The reinforced structure recited in claim 3, wherein said automotive rail section is a front rail.

5. The reinforced structure recited in claim 3 or 4, wherein said rail section is C-shaped with outwardly extending flanges, and a cap plate secured to said flanges.

6. The reinforced structure recited in any of the preceding claims, wherein said opposed walls (70, 72) are welded to said structural member (52).

7. The reinforced structure recited in any of the preceding claims, wherein said sleeve (81) is welded to at least one

of said first and second walls (70, 72).

8. The reinforced structure recited in any of the preceding claims, wherein said reinforced structural member has a pair of through holes in alignment with said bolt-receiving passage of said sleeve.

9. The reinforced structure recited in any of the preceding claims, wherein said layer of expanded polymer (74) is an epoxy.

10. The reinforced structure recited in any of the preceding claims, wherein said sleeve is substantially parallel with said first and second opposed walls.

11. The reinforced structure recited in any of the preceding claims, wherein said layer of expanded polymer is thermally expanded and formed from, in percentage by weight, from 40% to 60% resin; from 10% to 50% microspheres; from 0.5% to 5% blowing agent; from 1% to 15% filler; from 0.5% to 2.0% accelerator and from 1% to 8% curing agent.

12. A reinforced structure as claimed in any of the preceding claims, wherein the sleeve (81) is mounted totally within and is fully enclosed by the walls and resin.

13. The reinforced structural member of claim 5, wherein said rail is made of steel, and said walls having flanges are welded to said steel rail.

14. The reinforced structural member recited in claim 1 wherein the first and second opposed walls each include curved inner surface at the position of said sleeve.

15. A reinforced structure as claimed in any of the preceding claims, wherein the sleeve (81) is of a closed circular cross-section.

16. The reinforced structure recited in claim 9, wherein said epoxy is thermally expanded and further contains microspheres which reduces the density of said epoxy.

17. A method of reinforcing a structural member (52) having a longitudinal channel (56) therethrough, comprising the steps of: providing a structural member which defines a longitudinal channel; providing a laminated structure (68) having two opposed walls (70, 72) separated by a layer of expandable polymer; said laminated structure has a sleeve (81); which is formed as a bushing, and is fixed in said layer of expandable polymer, said sleeve (81) defining a passage adapted to receive a bolt between said opposed walls (70, 72); placing said laminated structure in said longitudinal channel (56) such that said sleeve passage is substantially perpendicular to said longitudinal channel (56); fixing said laminated structure to said structural member (52); and actuating said polymer to expand into intimate contact with said walls (70, 72) and said sleeve (81).

18. The method recited in claim 17, wherein the polymer is thermally expandable, in which said structural member (52) is heated to a temperature sufficient to thermally expand said layer of thermally expandable polymer such that said polymer bonds said laminated structure to said structural member.

19. The method recited in claim 17, wherein said structural member is an automotive rail.

20. The method recited in claim 18, wherein said epoxy further includes microspheres which reduce the density of said epoxy.

21. A reinforcing member (68) comprising first (70) and second (72) opposed walls, a sleeve defining a passage adapted to receive a bolt (81) disposed between said first (70) and second (72) walls, characterised in that said sleeve is formed as a bushing and an expandable polymer is disposed within said reinforcing member (68) such that it can be expanded to bond to said first (70) and second (72) opposed walls and said sleeve (81).

**Patentansprüche**

1. Verstärkte Struktur (50), die ein einen Raum (56) begrenzendes Strukturelement (52); ein Verstärkungselement

(68) angeordnet in dem genannten Raum, wobei das genannte Verstärkungselement eine erste (70) und zweite (72) gegenüberliegende Wand aufweist, und eine Schicht aus ausgedehntem Polymer (74) umfaßt, die zwischen der genannten ersten und zweiten gegenüberliegenden Wand angeordnet und an dieselben gebunden ist, wobei das genannte ausgedehnte Polymer auch an das genannte Strukturelement gebunden wird; dadurch gekennzeichnet, daß eine als eine Buchse ausgebildete Hülse (81) sich durch das genannte ausgedehnte Polymer (74) erstreckt, wobei die genannte Hülse (81) zwischen der genannten ersten (70) und zweiten (72) gegenüberliegenden Wand befestigt ist, das genannte ausgedehnte Polymer an die genannte Hülse (81) gebunden wird; und die genannte Hülse einen zur Aufnahme eines Bolzens (84) ausgeführten Durchgang begrenzt.

2. Verstärkte Struktur nach Anspruch 1, die weiter einen Bolzen (84) umfaßt, der sich durch das genannte Strukturelement (52) erstreckt, und der sich durch die genannte Hülse (81) erstreckt.

3. Verstärkte Struktur nach Anspruch 1 oder 2, bei der die genannte verstärkte Struktur ein Fahrzeugschienenabschnitt ist.

4. Verstärkte Struktur nach Anspruch 3, bei der der genannte Fahrzeugschienenabschnitt eine Vorderschiene ist.

5. Verstärkte Struktur nach Anspruch 3 oder 4, bei der der genannte Schienenabschnitt C-förmig mit sich nach außen erstreckenden Flanschen und einer an die genannten Flansche befestigten Kappenplatte ist.

6. Verstärkte Struktur nach einem der vorhergehenden Ansprüche, bei der die genannten gegenüberliegenden Wände (70, 72) an das genannte Strukturelement (52) geschweißt sind.

7. Verstärkte Struktur nach einem der vorhergehenden Ansprüche, bei der die genannte Hülse (81) an wenigstens eine der genannten ersten und zweiten Wand (70, 72) geschweißt ist.

8. Verstärkte Struktur nach einem der vorhergehenden Ansprüche, bei der das genannte verstärkte Strukturelement ein Paar Durchgangslöcher ausgerichtet mit dem genannten Bolzenaufnahmedurchgang der genannten Hülse aufweist.

9. Verstärkte Struktur nach einem der vorhergehenden Ansprüche, bei der die genannte Schicht aus ausgedehntem Polymer (74) ein Epoxidharz ist.

10. Verstärkte Struktur nach einem der vorhergehenden Ansprüche, bei der die genannte Hülse im wesentlichen parallel mit der genannten ersten und zweiten gegenüberliegenden Wand ist.

11. Verstärkte Struktur nach einem der vorhergehenden Ansprüche, bei der die genannte Schicht aus ausgedehntem Polymer wärmeausgedehnt wird und, angegeben in Gewichtsprozent, aus 40% bis 60% Harz; von 10% bis 50% Mikrokugeln; von 0,5% bis 5% Treibmittel; von 1% bis 15% Füllstoff; von 0,5% bis 2,0% Beschleuniger und von 1% bis 8% Härtungsmittel gebildet wird.

12. Verstärkte Struktur nach einem der vorhergehenden Ansprüche, bei der die Hülse (81) vollständig innerhalb der Wände und des Harzes angebracht und völlig von ihnen umschlossen wird.

13. Verstärktes Strukturelement von Anspruch 5, bei dem die genannte Schiene aus Stahl hergestellt ist, und die genannten Wände, die Flansche aufweisen, an die genannte Stahlschiene geschweißt sind.

14. Verstärktes Strukturelement nach Anspruch 1, bei dem die erste und zweite gegenüberliegende Wand an der Position der genannten Hülse jeweils eine gekrümmte Innenfläche aufweisen.

15. Verstärkte Struktur nach einem der vorhergehenden Ansprüche, bei der die Hülse (81) einen geschlossenen kreisförmigen Querschnitt hat.

16. Verstärkte Struktur nach Anspruch 9, bei der das genannte Epoxidharz wärmeausgedehnt wird und weiter Mikrokugeln enthält, die die Dichte des genannten Epoxidharzes verringern.

17. Verfahren zum Verstärken eines Strukturelements (52) mit einem durch dasselbe gebildeten Längskanal (56), das die Schritte aufweist: ein Strukturelement vorzusehen, das einen Längskanal begrenzt; eine laminierte Struktur

(68) mit zwei durch eine Schicht aus ausdehnbarem Polymer getrennten gegenüberliegenden Wänden (70, 72) vorzusehen; wobei die genannte laminierte Struktur eine als eine Buchse ausgebildete Hülse (81) umfaßt, die in der genannten Schicht aus ausdehnbarem Polymer befestigt ist, wobei die genannte Hülse (81) einen Durchgang begrenzt, der zum Aufnehmen eines Bolzens zwischen den genannten gegenüberliegenden Wänden (70, 72) ausgeführt ist; die genannte laminierte Struktur in dem genannten Längskanal (56) so anzuordnen, daß der genannte Hülsendurchgang im wesentlichen senkrecht zu dem genannten Längskanal (56) ist; die genannte laminierte Struktur an dem genannten Strukturelement (52) zu befestigen, und das genannte Polymer zum Ausdehnen in engen Kontakt mit den genannten Wänden (70, 72) und der genannten Hülse (81) zu aktivieren.

**18.** Verfahren nach Anspruch 17, bei dem das Polymer wärmeausdehnbar ist, wobei das genannte Strukturelement (52) auf eine Temperatur erhitzt wird, die zum Wärmeausdehnen der genannten Schicht aus wärmeausdehnbarem Polymer ausreicht, so daß das genannte Polymer die genannte laminierte Struktur an das genannte Strukturelement bindet.

**19.** Verfahren nach Anspruch 17, bei dem das genannte Strukturelement eine Fahrzeugschiene ist.

**20.** Verfahren nach Anspruch 18, bei dem das genannte Epoxidharz weiter Mikrokugeln enthält, die die Dichte des genannten Epoxidharzes verringern.

**21.** Verstärkungselement (68), das eine erste (70) und zweite (72) gegenüberliegende Wand und eine Hülse aufweist, die einen zum Aufnehmen eines Bolzens (81) ausgeführten Durchgang begrenzt, der zwischen der genannten ersten (70) und zweiten (72) Wand angeordnet ist, dadurch gekennzeichnet, daß die genannte Hülse als eine Buchse ausgebildet ist und ein ausdehnbares Polymer innerhalb des genannten Verstärkungselements (68) angeordnet ist, so daß es zum Binden an die genannte erste (70) und zweite (72) gegenüberliegende Wand und die genannte Hülse (81) ausgedehnt werden kann.

**Revendications**

**1.** Structure renforcée (50), comprenant un élément structurel (52) définissant un espace (56) ; un élément de renforcement (68) disposé dans ledit espace, ledit élément de renforcement ayant des première (70) et deuxième (72) parois opposées ; une couche de polymère expansé (74) disposée entre lesdites et collée auxdites première et deuxième parois opposées, ledit polymère expansé étant également collé audit élément structurel ; caractérisée en ce qu'un manchon (81), formé sous forme de douille, s'étend à travers ledit polymère expansé (74), ledit manchon (81) étant fixé entre lesdites première (70) et deuxième (72) parois opposées, ledit polymère expansé étant collé audit manchon (81) ; et ledit manchon définissant un passage adapté en vue de recevoir un boulon (84).

**2.** Structure renforcée selon la revendication 1, comportant en outre un boulon (84) qui s'étend à travers ledit élément structurel (52) et qui s'étend à travers ledit manchon (81).

**3.** Structure renforcée selon la revendication 1 ou 2, dans laquelle ladite structure renforcée est un profil de longeron automobile.

**4.** Structure renforcée selon la revendication 3, dans laquelle ledit profil de longeron automobile est un longeron avant.

**5.** Structure renforcée selon la revendication 3 ou 4, dans laquelle ledit profil de longeron est en forme de C avec des brides s'étendant vers l'extérieur, et une plaque de recouvrement fixée auxdites brides.

**6.** Structure renforcée selon l'une quelconque des revendications précédentes, dans laquelle lesdites parois opposées (70, 72) sont soudées audit élément structurel (52).

**7.** Structure renforcée selon l'une quelconque des revendications précédentes, dans laquelle ledit manchon (81) est soudé à au moins une desdites première et deuxième parois (70, 72).

**8.** Structure renforcée selon l'une quelconque des revendications précédentes, dans laquelle ledit élément structurel renforcé comporte une paire de trous débouchants en alignement avec ledit passage receveur de boulon dudit manchon.

9. Structure renforcée selon l'une quelconque des revendications précédentes, dans laquelle ladite couche de polymère expansé (74) est un matériau époxy.

10. Structure renforcée selon l'une quelconque des revendications précédentes, dans laquelle ledit manchon est sensiblement parallèle auxdites première et deuxième parois opposées.

11. Structure renforcée selon l'une quelconque des revendications précédentes, dans laquelle ladite couche de polymère expansé est expansée thermiquement et formée à partir de, en pourcentage de poids, 40% à 60% de résine ; 10% à 50% de microsphères ; 0,5% à 5% de gonflant ; 1% à 15% de matière de remplissage ; 0,5% à 2,0% d'agent accélérateur et 1% à 8% d'agent de vulcanisation.

12. Structure renforcée selon l'une quelconque des revendications précédentes, dans laquelle le manchon (81) est monté entièrement à l'intérieur des et est complètement enfermée par les parois et la résine.

13. Elément structurel renforcé selon la revendication 5, dans laquelle le longeron est réalisé en acier, et lesdites parois à brides sont soudées audit longeron en acier.

14. Elément structurel renforcé selon la revendication 1, dans lequel les première et deuxième parois opposées comportent chacune une surface interne courbe au niveau de la position dudit manchon.

15. Structure renforcée selon l'une quelconque des revendications précédentes, dans laquelle le manchon (81) est une coupe transversale circulaire fermée.

16. Structure renforcée selon la revendication 9, dans laquelle ledit matériau époxy est expansé thermiquement et contient en outre des microsphères, ce qui réduit la densité dudit matériau époxy.

17. Procédé de renforcement d'un élément structurel (52) traversé par une gorge longitudinale (56), comprenant les étapes de : fourniture d'un élément structurel qui définit une gorge longitudinale ; fourniture d'une structure laminée (68) ayant deux parois opposées (70, 72) séparées par une couche de polymère expansible ; ladite structure laminée a un manchon (81), formé sous forme de douille, fixé dans ladite couche de polymère expansible, ledit manchon (81) définissant un passage adapté en vue de recevoir un boulon entre lesdites parois opposées (70, 72); placement de ladite structure laminée dans ladite gorge longitudinale (56) de telle sorte que ledit passage de manchon soit sensiblement perpendiculaire à ladite gorge longitudinale (56) ; fixation de ladite structure laminée audit élément structurel (52) ; et actionnement dudit polymère pour qu'il se dilate en contact intime avec lesdites parois (70, 72) et ledit manchon (81).

18. Procédé selon la revendication 17, dans lequel le polymère est expansible thermiquement, dans lequel ledit élément structurel (52) est chauffé à une température suffisante pour dilater thermiquement ladite couche de polymère expansible thermiquement de telle sorte que ledit polymère colle ladite structure laminée audit élément structurel.

19. Procédé selon la revendication 17, dans lequel ledit élément structurel est un longeron automobile.

20. Procédé selon la revendication 18, dans lequel ledit matériau époxy comporte en outre des microsphères qui réduisent la densité dudit matériau époxy.

21. Elément de renforcement (68) comprenant des première (70) et deuxième (72) parois opposées, un manchon définissant un passage adapté en vue de recevoir un boulon (81) disposé entre lesdites première (70) et deuxième (72) parois, caractérisé en ce que ledit manchon est formé sous forme de douille et un polymère expansible est disposé au sein dudit élément de renforcement (68) de manière à pouvoir être dilaté en vue de se coller auxdites première (70) et deuxième (72) parois opposées et audit manchon (81).

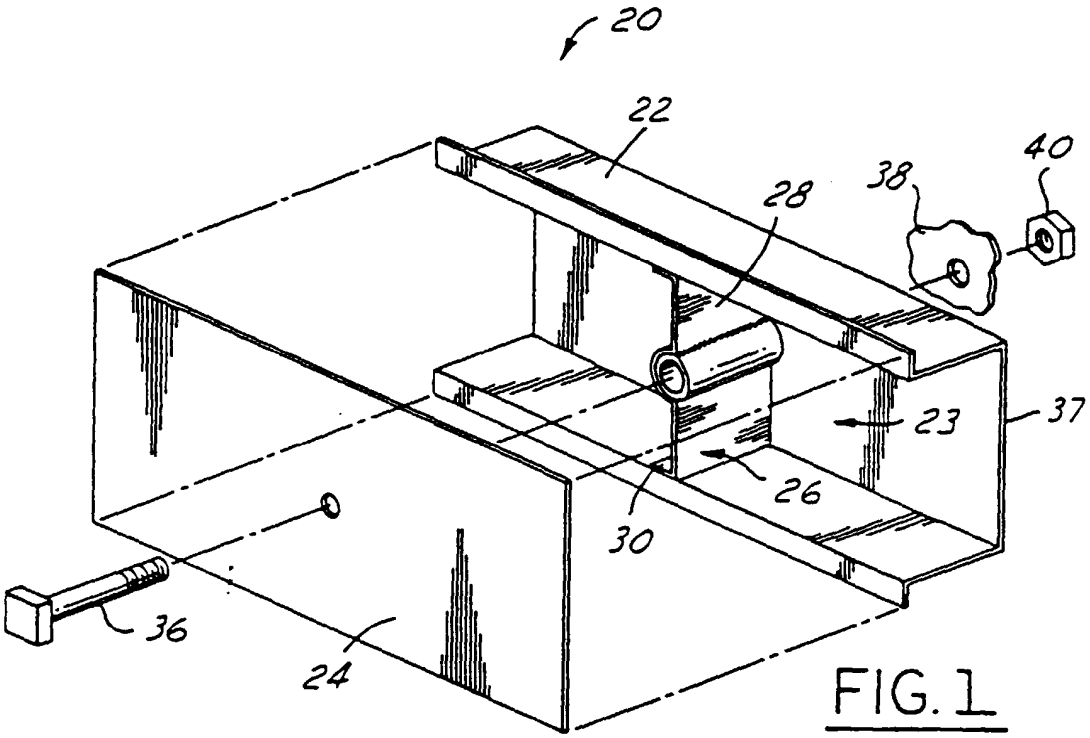


FIG. 1
(Prior Art)

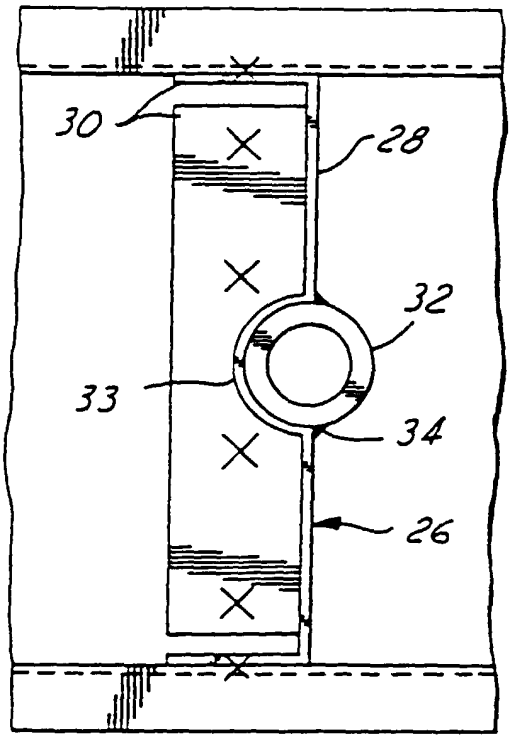


FIG. 2 (Prior Art)

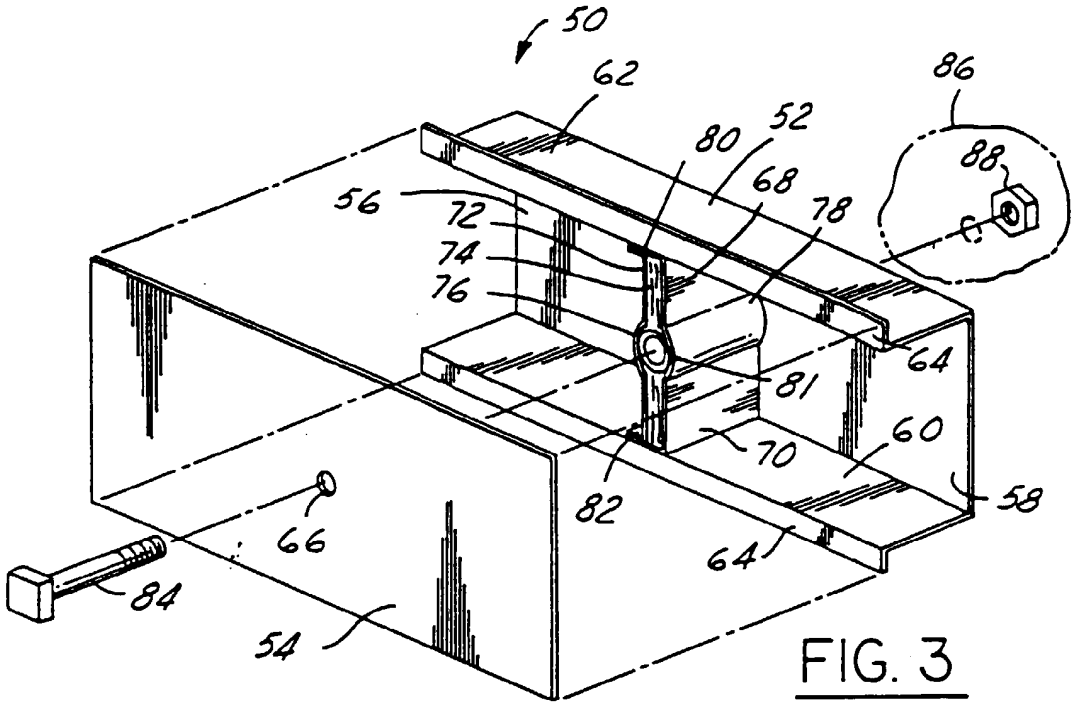


FIG. 3

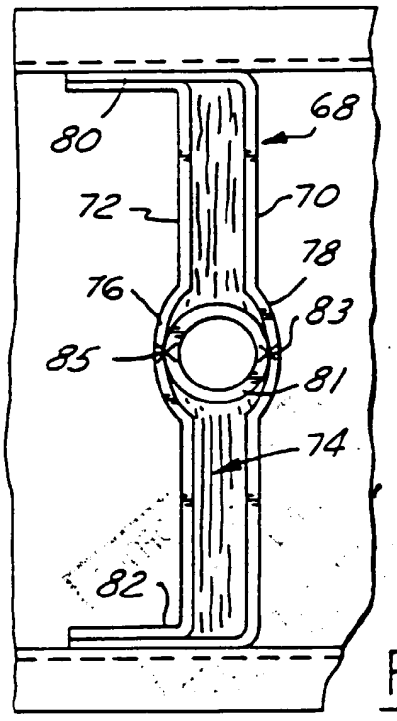


FIG. 4

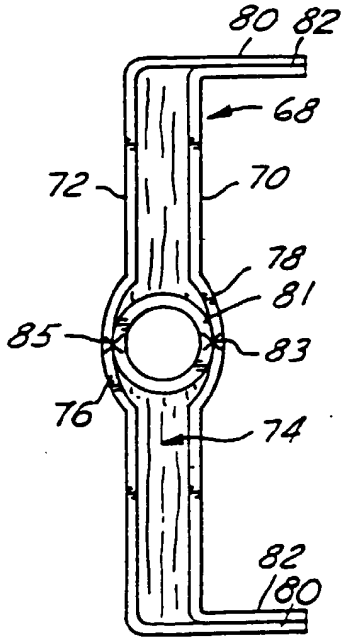


FIG. 5